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GROUND WATER ISSUES IN THE NORTH

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MANAGEMENT PERSPECTIVE

This report describes the need for specific ground water studies in the North. Monitoring of leakage from the tailings ponds at the Canada Tungsten mine and regional hydrogeologic monitoring in Wood Buffalo National Park are discussed in some detail. Research on northern hydrogeologic processes and monitoring of resource developments are identified as programs requiring ground water investigations in the future. Uranium mining is singled out as a special case apart from the general category of mining-related ground water issues, because of the Federal Government's responsibility for uranium mining and the nuclear fuel cycle.

PERSPECTIVE DE GESTION

Selon le présent rapport, il faut procéder à des études précises des eaux souterraines dans le nord. Le rapport examine en détail la surveillance des fuites des bassins à stériles de la mine Canada Tungsten et la surveillance régionale hydrogéologique au parc national Wood Buffalo. Les recherches sur les processus hydrogéologiques dans le nord et la surveillance de la mise en valeur des ressources sont présentées comme étant des programmes nécessitant des recherches sur l'eau souterraine à l'avenir. L'exploitation minière de l'uranium a été choisie comme un cas spécial qui n'appartient pas à la catégorie générale de questions reliées à l'exploitation minière et concernant l'eau souterraine, du fait de la responsabilité du gouvernement fédéral à l'égard de l'exploitation minière de l'uranium et du cycle du combustible nucléaire.

ABSTRACT

The study of ground water issues in northern Canada is still in its infancy. Because of the sparse population in Canada's north, most ground water quality issues which arise there have not so much to do with the quality of the ground water itself for drinking, but with the eventual effects of ground water quality on surface water quality. Because of the extremely high cost of broad-scale monitoring programs, any study of ground water movement and quality in the North must be directed toward specific, identifiable issues. In relation to the mining industry, these issues may have to do with the integrity of holding ponds, or the quality of water which has seeped through tailings piles or mine workings. The mining related ground water investigations are of particular importance where excessive concentrations of dissolved metals, acid, or radionuclides have been generated by leaching. Ground water quality degradation may also occur due to the deposition of atmospheric pollutants in poorly buffered ground waters. On perhaps a lesser scale, municipal sewage effluent has the potential to contaminate ground water through leakage from lagoons before biodegradation of wastes can proceed to completion. In general, the scope of possible ground water monitoring activities is immense, and there are many areas where information is lacking as to where monitoring is needed, and for what substances.

RÉSUMÉ

L'étude des questions relatives à l'eau souterraine dans le nord du Canada en est encore à ses débuts. Du fait de la faible population de cette région, la plupart des questions relatives à la qualité de l'eau souterraine qui sont soulevées dans cette région ne concernent pas tellement la qualité d'eau potable de l'eau souterraine elle-même mais surtout les répercussions éventuelles de la qualité des eaux souterraines sur la qualité des eaux de surface. Du fait du coût extrêmement élevé des programmes de surveillance à grande échelle, toute étude du mouvement et de la qualité des eaux souterraines dans le nord doit porter sur des questions particulières et identifiables. Les questions qui se rapportent à l'industrie minière concernent l'intégrité des étangs de retenue, ou la qualité de l'eau qui a filtré à travers les tas de rebuts ou les sièges d'extraction. Les recherches sur l'eau souterraine se rapportant à l'exploitation minière sont particulièrement importantes là où des concentrations excessives de métaux, d'acide ou de radionucléides dissous sont dues au lessivage. La dégradation de la qualité de l'eau souterraine peut également être due au dépôt de polluants atmosphériques dans les eaux souterraines mal tamponnées. Sur une plus petite échelle, les eaux résiduelles municipales peuvent peut-être contaminer les eaux souterraines par des fuites des bassins d'épandage avant que la biodégradation des déchets puisse avoir lieu jusqu'au bout. En général, l'étendue des activités possibles de surveillance des eaux souterraines est immense, et il y a bon nombre de secteurs où il n'y a aucune information sur les lieux où la surveillance est nécessaire et pour quelles substances.

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1.0 INTRODUCTION

It is generally recognized that ground water monitoring must be targeted toward specific issues or problems because of the high costs involved in the monitoring process. This is particularly true in Northern Canada where the low population density and the large areas encompassed make large scale ground water monitoring programs impractical. Because ground water research must be designed to address specific problems and issues, it must also be designed to investigate the ground water environment in particular locations. Research on northern ground water problems, then, must be done in the North, at the site of the problem.

This raises the question, however, why ground water research in such a large sparsely populated region as Canada's North is needed at all. On the face of it, because ground water resources in the North have not been tapped on a large scale for domestic, municipal, or industrial supply, ground water problems would seem to have low priority and expending limited research resources on them would appear unnecessary. The answer is that ground water and surface water are directly connected, and that ground water problems and issues impinge directly on issues of surface water quality.

2.0 GROUND WATER/SURFACE WATER INTERACTION

Ground water movement is much slower than surface water movement. Hence the dissemination of contaminants in ground water is a much slower, more insidious process.

Water entering the ground water zone will move off in a direction and at a velocity governed by the configuration of the flow system and on the physical characteristics of the aquifer. Under most conditions this means it will flow from an area of higher elevation to one of lower elevation. When a ground water flow system intersects the land surface, ground water discharge will occur, usually into a surface water body such as a lake or a stream. Generally speaking, water which infiltrates and becomes ground water will eventually discharge and either become part of the surface water regime if the ground water flux is sufficiently rapid, or will evaporate if the seepage rate is very slow. When ground water is contaminated, then, it will eventually carry the contaminant to the surface. The contaminant will then be disseminated by surface water movement and become biologically available.

The rationale for environmental ground water studies in the North, or anywhere else for that matter, is that a ground water contamination problem will eventually become a surface water contamination problem. When one considers the area of the North, and the loadings of atmospheric contaminants which it is becoming increasingly evident that the North receives, then the potential for widespread contamination of both ground water and surface water becomes disturbingly obvious.

3.0 FOCUS ON GROUND WATER RESEARCH IN THE NORTH

Although some large scale monitoring of ground water quality and quantity has been undertaken by provincial agencies in the south, this cannot be done economically in northern Canada. Ground water research and monitoring must focus on specific issues.

There are two main categories of ground water issues in the north: the operational and the research-oriented. The operational issues are dealt with on a cost-recovered, client-driven basis. The research-oriented issues are those which are dealt with as research topics, and are funded by the agency doing the research.

Some examples of ground water issues are presented below.

I. OPERATIONAL GROUND WATER ISSUES

A. Impact on ground water due to industrial activity

1. Mining industry

- a. Tailings piles
- b. Mine decommissioning
- c. Mine drainage
- d. Holding pond integrity
- e. Uranium mining

2. Oil and gas industry

- a. Pipelines
- b. Road construction
- c. Other construction

B. Municipal development

1. Landfill sites
2. Sewage disposal
3. Water supply

C. Regional hydrogeological studies

1. Ground water resource evaluation
2. Geochemical prospecting
3. Delineation of long-term trends in ground water quality and quantity

II. RESEARCH-ORIENTED GROUND WATER ISSUES

C. Atmospheric transport of contaminants; the potential to affect ground water quality

1. Release of contaminants due to reactions between acidified ground water and the rock matrix
2. Processes affecting the fate of contaminants in representative terranes
3. Monitoring for contaminants

D. PERMAFROST

1. Hydrogeologic characteristics of permafrost
2. The effect of climatic change on permafrost
3. Contaminant movement through the continuous and discontinuous zones.
4. The effect of ground water related features on physical works, such as pipelines and roads.

4.0 CURRENT NHRI RESEARCH PROJECTS

The National Hydrology Research Institute's ground water research program in the North is still in the developmental stage, and does not yet address a representative cross-section of the ground water issues outlined above. However, a description of some projects will serve to illustrate how NHRI is attempting to address some of them.

4.1 The Mine at Canada Tungsten, Tungsten NWT

The Canada Tungsten mine is located in the District of Franklin, near the Yukon Border. It occupies the east-west trending valley of the Flat River, which is a tributary of the South Nahanni, which flows through Nahanni National Park (Figure 1). The most important ground water issue related to the operation of the mine is the quality of exfiltrate from two tailings ponds which were used until the mine was shut down in 1986, and from two previously decommissioned tailings ponds (Figure 1 ;Sigma Resource Consultants Ltd, 1981). Monitoring of ground water quality below the ponds has been carried out over recent years to ensure that contaminant levels in the ground water remain below the objectives set in the mine license.

Leakage from the tailings ponds has the potential to contaminate the Flat River. In fact, the ponds were designed to leak so that copper and cyanide complexes in the tailings fluids could be sorbed onto colloidal substances in the underlying sediments and thereby be removed from the exfiltrating tailings water. The geochemical reactions involve the mineral pyrrhotite (an iron sulphide), which has the ability to complex these species and render them insoluble.

NHRI has been involved mainly in the environmental impact assessment and in the license renewal for the mine, in an advisory role to the Northwest Territories Water Board and to Indian and Northern Affairs Canada (INAC) (Canada Tungsten Mining Corp, 1982). Despite the mine's closure in 1986, monitoring of tailings seepage must continue in order to ensure that the metals and cyanide complexes will be not be remobilized. INAC has fulfilled the monitoring function since 1975.

The holding ponds are situated behind tall dykes which overlook the Flat River (Figure 2). Exfiltration is monitored by means of a network of piezometers situated at the sites shown in Figure 2 (Sigma Resource Consultants, 1981).

The valley bottom sediments are coarse grained alluvial sands and gravels, and are very permeable. An estimated 2000 cubic metres of tailings water per day seeped out of the bottom of ponds 3 and 4 while the mine was in operation. Seepage was slowed somewhat by the intentional beaching of tailings against the pond walls. The tailings are very fine, and are less permeable than the materials making up the bottoms and walls of the ponds.

Waste liquid in the ground moves with the ground water in a cross-valley direction towards the river, and discharges from a seepage area along the river (Figure 3).

The monitoring data have so far indicated that the sorption of the cyanide and copper complexes by the colloidal fraction must be an effective mechanism. Concentrations of copper and cyanide in the Flat River have remained consistently below the maximum permissible levels specified in the mine license (Sigma Resource Consultants Ltd, 1983).

The ground water monitoring work at Canada Tungsten shows how ground water processes can affect surface water quality, and how a monitoring program can be designed to help prevent surface water contamination.

4.2 Regional Hydrogeology of Wood Buffalo National Park

Wood Buffalo National Park is located on the Alberta-NWT boundary. NHRI's involvement with the Park arose originally in 1982, when massive dewatering from Pine Point Mine some 60 km north of the Park Boundary caused some concern about the drying up of the ponds throughout the nesting ground of the world's only remaining breeding population of whooping cranes. With the cessation of dewatering at Pine Point in early 1987, the concerns about continued drawdown were allayed. However, Parks Canada, INAC, and Canadian Wildlife Service personnel are still interested in understanding more about the long-term stability of the ponds in the nesting area (Figure 4).

It is thought that some of the ponds in the Park are ground water fed, and that the huge karstic area in the Park, shown in figure 4, is a discharge zone. This is not surprising, because the Paleozoic/Precambrian boundary stretching from the Arctic to southern Manitoba is characterized by discharge conditions brought about by the termination of regional flow systems originating in the Western Canada Sedimentary Basin.

With respect to the discharge zone in the Park, the following questions arise: where does the ground water originate? What are the chances that the groundwater supplies to the ponds could dry up? Are there any significant long term trends in either water quality or quantity in the Park?

Various hypotheses have been put forth concerning the ground water flow systems of this area. One suggestion is that the entire Park region is a great piece of "swiss cheese", and that the major aquifers in the region are all interconnected by a system of faults and fractures. This would mean that the rate of ground water flow through the bedrock is very rapid, and that the storage capacity of the aquifer is very low. If that were the case, ground water levels throughout the entire region would be very sensitive to climate change or to the removal of ground water from the flow system by pumping. The surface water levels in Wood Buffalo Park would accordingly be less stable, and the long-term viability of the ponds less assured.

In order to determine whether or not the wetlands in Wood Buffalo Park would be affected by ground water withdrawals or by short-term climatic change, Parks Canada has asked NHRI to assess the regional hydrology of the Park and to investigate the stability of the ponds.

The study proposed by NHRI consists of on-going measurement of water levels in the ponds, hydrochemical and stable isotope sampling, the interpretation of aerial photography, and the use of LANDSAT data. Ground water levels will be monitored in several shallow piezometers installed in three study areas by NHRI in 1985. Measurement of ground water discharge from two major springs near the north end of the Park will be continued, and biophysical resource data collected by Parks personnel will be used to "ground truth" the aerial photographs and the LANDSAT images. The study is expected to take four years to complete.

The data collected over the course of the study will show whether over the next few years there is any discernible trend to lower flows in the springs, or to a consistent lowering of either surface water or ground water levels in the region. It will also make it possible to see whether there is a consistent rise in water levels which could be attributed to the cessation of pumping at Pine Point. It will allow researchers to see if ground water in the region is affected by climatic influences, or whether the flow system contributing to the ground water regime in the Park is so large as to make short-term changes in ground water supply to the ponds indiscernible.

The remote sensing component of the study will allow researchers to delineate the major discharge zone which feeds the surface water bodies of the Park. If the ponds are being fed by a regional ground water flow system which debouches in the karstic region of the Park rather than

being maintained by precipitation input, then this would be an indication that the ponds are not going to be affected by short-term climatic change, and that only an extremely long drought would cause an excessive loss of water from the area.

5.0 URANIUM MINING

Mines produce large quantities of waste rock. Precipitation percolates through the tailings piles, and attacks the minerals which make up the rock. This results in the mobilization of rock constituents in the leachate. The result can be the contamination of ground and surface waters with metals and inorganic acids. In the case of radionuclides the problem of leachate generation from tailings piles and mine works is particularly sensitive. Decommissioned mine sites where tailings piles have been left to interact freely with infiltrating water are a major environmental concern in the North.

Because the problem of tailings disposal is essentially one of the control of water infiltration and movement in a permeable medium, it is a ground water issue. The basic goal of environmental agencies is to prevent the escape of toxic substances from tailings piles, waste ponds, and mine workings. In order to meet this goal, mine operators must be provided with firm guidelines and regulations concerning dewatering water disposal, holding pond integrity, tailings disposal, and decommissioning. Monitoring the levels and quality of ground water throughout the area of the mine is also necessary to provide early warning of contamination problems which will need correction.

The regulatory and inspection function falls within the Federal Mandate, and is the responsibility of the Atomic Energy Control Board. Environment Canada acts in an advisory role through the Environmental Assessment Review Process. Part of this advisory role is the review of Environmental Impact Statements. Researchers in Environment Canada therefore have the opportunity to provide advice to AECB on the environmental soundness of mining plans, and to recommend changes. The technical work arising from the inspection of Environmental Impact Statements includes baseline data review, the review of the proponent's design of holding facilities, and contingency measures to be taken in the event of a spill. Other considerations include dewatering plans, the means of waste water disposal, and the projected effect of waste water escape on the environment.

6.0 CONCLUSION

Ground water plays a very important part in the health of the northern environment. Because it is not widely used as a source of supply in the Territories, however, its importance has not been fully recognized in the past. Ground water and surface water issues have often been considered to be unrelated, although in fact ground water and surface water are merely different stages in the hydrologic cycle and are intimately related. Arbitrarily separating surface water and ground water into discrete compartments, therefore may obscure the fact that the inevitable result of unrestrained ground water contamination will ultimately be the contamination of surface water.

It is the task of environmental agencies to ensure that economic development of Northern resources is accompanied by adequate measures for the protection of ground water quality. It is the task of researchers to understand the physico-chemical nature of ground water flow systems in the North, and to assess the present state of ground water resources. Researchers must determine whether or not fundamental changes in ground water quality and quantity are occurring, what the nature of these changes are, and what remedial actions should be taken to prevent ground water deterioration.

This report summarizes the kinds of ground water problems and issues faced, and presents some examples of how these may be addressed through ground water monitoring and research.

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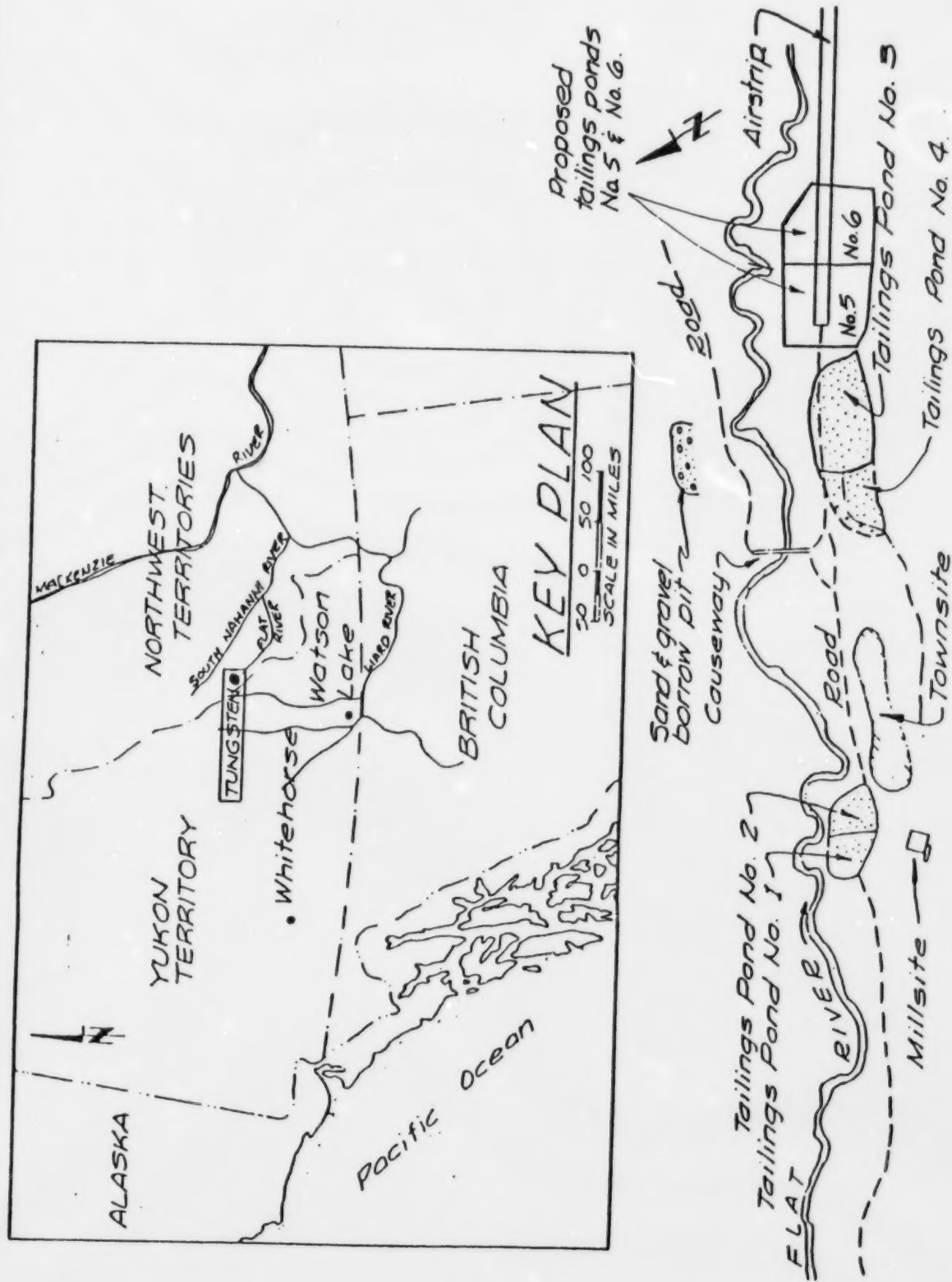


Figure 1. Site Location Plan and Key Plan: Canada Tungsten Mine

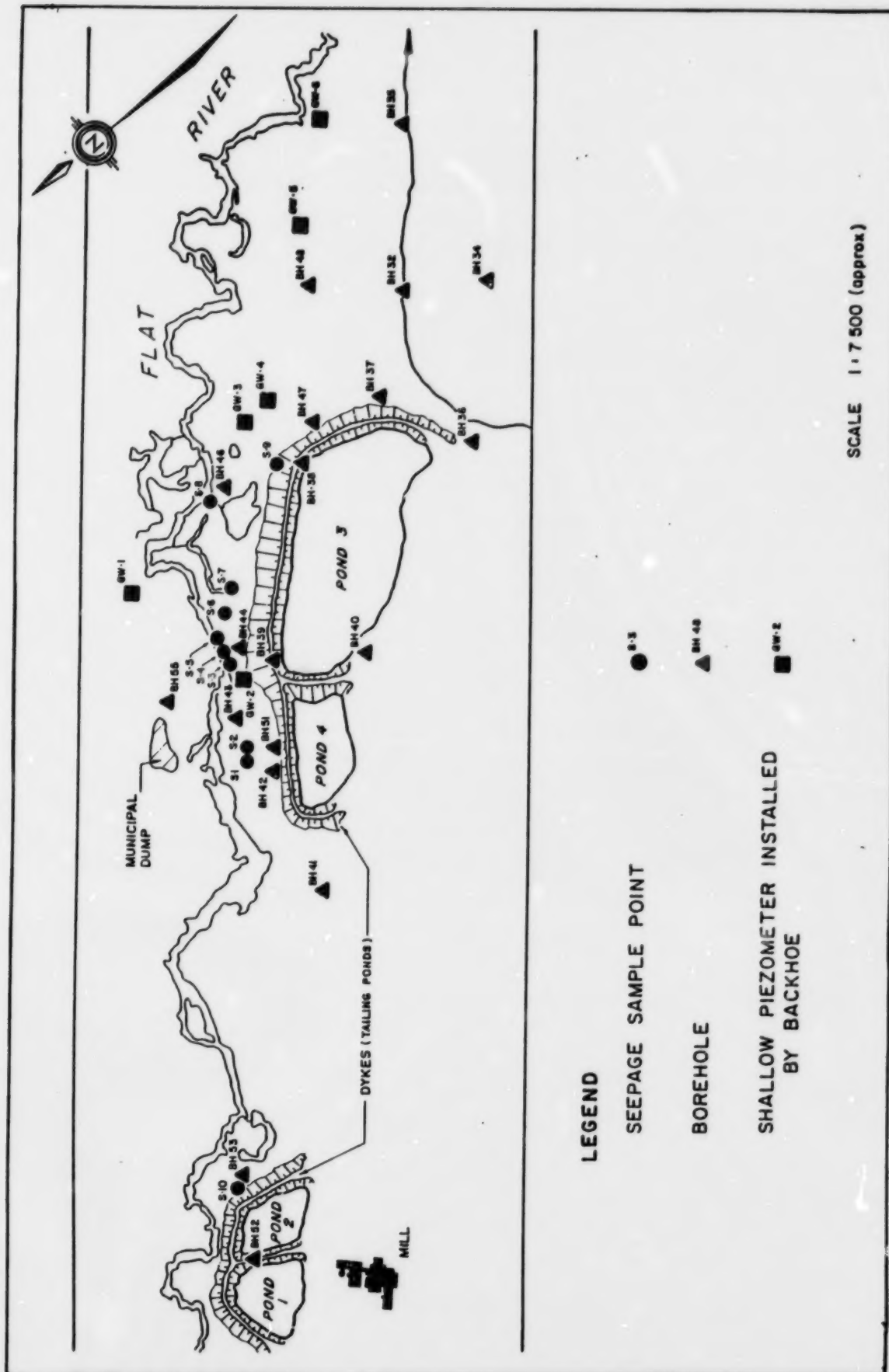


Figure 2. Borehole and Seepage Point Locations-Tailings Pond Area, Canada Tungsten

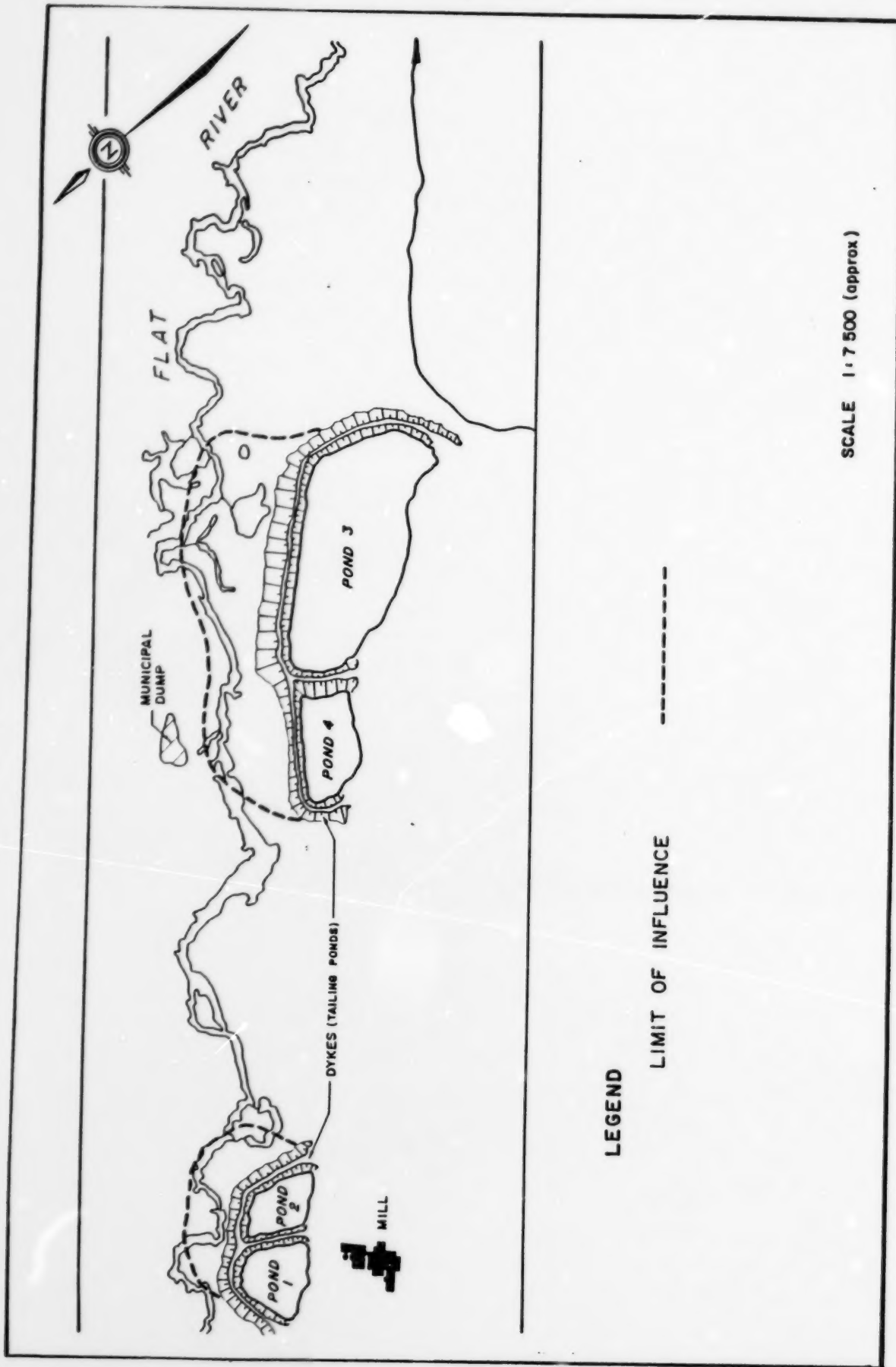


Figure 3. Estimated Extent of Water Quality Influenced
from the Tailings Ponds-Canada Tungsten Mine

